6.0 -- Raster Graphics Representation in Binary Format (MIL-PRF-28002)

6.1 -- Purpose

The MIL-PRF-28002 specification establishes requirements for a standard interchange file format and raster encoding scheme for raster data. MIL-PRF-28002 was first issued in December 1988. It was revised by MIL-PRF-28002A in November of 1990 and again by MIL-PRF-28002B, 14 December 1992. MIL-PRF-28002 Revision C is currently under development and is anticipated to be released by the Summer of 1997. This specification identifies the requirements to be met when raster data represented in digital, binary format is delivered to the Government.

Raster data involves the digital processing, storage, exchange and reproduction of bitmapped images. This technology supports the binary representation of a two-dimensional image as an array of picture elements, also known as pels. Each pel of the array contains information about that portion of the image. Note that the image in question may be a scan of text rather than a picture, which is why these images are usually called "raster data" rather than "raster graphics."

Revision C to MIL-PRF-28002 will permit four types of digital representation of raster data, called Type 1, Type 2, Type 3, and Type 4 in the specification:

a.   The Type 1 raster file format is used for raster data contained in a single monolithic block of compressed data and is called untiled raster data.

b.   The Type 2 raster file format is an Open Document Architecture (ODA) document (as specified by ISO 8613 ODA) conforming to a special Document Application Profile (DAP, found in FIPS PUB 194) for raster. Type 2 may be tiled raster data or may consist of a single compressed block of data as in Type 1, but with all ODA parameters and data structuring included. Due to its complexity and limited implementation, Type 2 is no longer recommended for use except in special cases as described in MIL-PRF-28002C.

c.   The Type 3 raster file format is the Navy Image File Format (NIFF). NIFF is a documented application profile (subtype) of Tagged Image File Format (TIFF) 5.0. NIFF is primarily intended for the end-use of scanned data. NIFF data files may be a mixture of tiled or untiled raster data, as needed.

d.   The Type 4 raster file format is the Joint Engineering Data Management Information and Control System (JEDMICS) C4 raster format. C4 data files are tiled. The Type 4 raster format is designed for data which is acquired for storage in a JEDMICS data depository. MIL-PRF-28002 Revision C is the first Publicly Available Specification (PAS) of the JEDMICS C4 format. Contrary to some reports, C4 is not a proprietary format, but is instead a Government-owned format which may be used license free.

Tiled raster data consists of an image that is subdivided into non-overlapping regions known as tiles where each tile is treated as a separate pel array. This method is especially useful for mechanical drawings in

which there are large open areas of space. Figure 10-1 shows an image overlayed with a grid coordinate system to produce the tile subdivisions. Within a single image, tiles are equal in size and their dimensions, specified in terms of pels, have certain limitations. Tiles can be compressed and manipulated to obtain an optimal raster file. However, it is possible that compression can result in an enlarged set of data ("negative compression"), especially in "busy" areas of the image. Therefore, compression must be employed with care. In such situations, an optimal raster file can be obtained using a mixture of compressed and uncompressed tiles. MIL-PRF-28002 specifies that individual tiles be digitized and the data compressed in accordance with Group 4 encoding defined in Recommendation T.6 (FIPS PUB 150). In cases where negative compression occurs, MIL-PRF-28002 recommends transmission of the uncompressed raster bitmap.
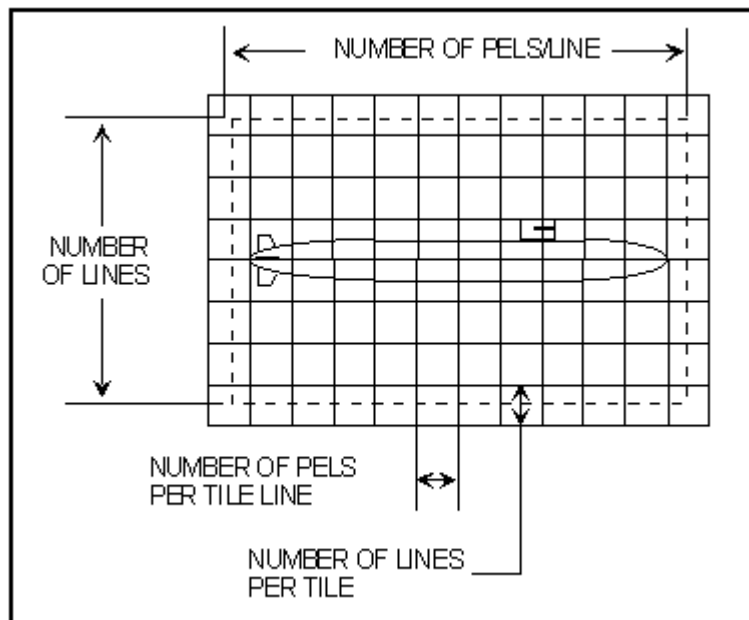

Figure 10-1 -- Tiled Raster Graphics Example.

6.2 -- Typical Applications

MIL-PRF-28002 was created for the storage and interchange of scanned engineering drawings but applies to other documents as well, such as technical manuals/technical orders and illustrations in raster form.

Type 1 raster is a simple bitonal graphics format, and is particularly useful for line drawings such as engineering data, or text. Type 1 raster data interchange is intended to be used in procuring data for systems that only use untiled raster data representations. A set of graphics attributes specifying the details necessary for processing and reproducing the image must be included in a header record at the beginning of the raster file. These attributes include the size of the original image, the scanning resolution, the image orientation (portrait or landscape), the starting position on the page, and the spacing between the pels and also between the lines containing the pels. These attributes are used in reproducing the image and now apply to only the Type 1 raster data file format.

Although the Type 2 ODA raster DAP is a good technical solution, it is complex and has not yet been fully

implemented in any systems. MIL-PRF-28002 recommends that Type 2 not be used for new Government procurements.

Tiled raster data interchange is best applied in systems handling large format drawings or illustrations typically associated with engineering design. The subdivision of a drawing into tiles allows the use of only those portions of an image required at a given time by the application. This can greatly reduce requirements for workstation memory and display, and allows faster access to portions of large format pages.

Type 3 raster data interchange allows a mixture of untiled and tiled images for multi-page documents with multiple page sizes and orientations. MIL-PRF-28002C Appendix A documents Type 3 raster data in detail so that this TIFF-based format can continue to be used even if the commercial TIFF standards are changed.

Type 4 raster data interchange is designed primarily for images destined for storage in a JEDMICS data repository, and is the native JEDMICS C4 image format. MIL-PRF-28002C Appendix B documents the C4 raster data file format as a PAS to make it accessible for all users and to encourage the development of off-the-shelf software tools for JEDMICS users. As currently written, Appendix B is only moderately detailed, as it is documentation based on existing programmer's notes. The JEDMICS Program Management Office (PMO) is in the process of documenting the C4 format in greater detail and with implementation guidance. The JEDMICS PMO will share this updated format specification with the CALS Digital Standards Office so that it can be published in an Amendment to MIL-PRF-28002C.

6.3 -- Status and Planned Extensions

MIL-PRF-28002B was published in December 1992. As a result of international harmonization activities, changes were made to the March 1993 version of the ODA Raster DAP, and the DoD decided that these changes were significant enough to warrant an amendment to MIL-PRF-28002B, which is the current revision.

The following is a list of technical changes that will be included in MIL-PRF-28002C scheduled to be published by the Summer of 1997:

- Clarifications to the encoding of MIL-STD-1840 raster data file header records and the raster data block for the Type 1 Untiled format.

- The removal of the requirements for the Type 2 Tiled/Untiled format and their inclusion "by reference" to FIPS PUB 194. As explained above, Type 2 is no longer recommended for the procurement of new project data.

- The inclusion of a Type 3 Tiled/Untiled format, NIFF.

- The documentation of the JEDMICS C4 format as a Type 4 Tiled format.

6.4 -- Implementation Issues

The development of Type 1 data capabilities has been evolving for some time and has stabilized. The CALS Test Network (CTN) digital raster data interchange testing for Type 1 data has aided many present and potential DoD contractors in their efforts to develop hardware and software that are technically capable of accomplishing MIL-PRF-28002 Type 1 interchanges. Although the CTN has been discontinued, their published test reports that describe Type 1 testing results for a variety of vendor implementations are expected to become available at the CALS Standards WWW site:

<**http://www-cals.itis.disa.mil**>

Since the Type 3 and Type 4 raster data formats are both employed in existing DoD imaging systems, some tools have already been implemented for their use. See MIL-PRF-28002C for guidance, or contact the CALS Digital Standards Office at the WWW site above for additional information on tool availability and on the implementation of these formats.

6.5 -- Extent and Nature of User and Vendor Support

The CTN and NIST have developed various tools for CALS raster data files, including validated raster data files which can be used to test tool compliance. Several commercial products can also save or convert a bitmapped file into one or more of the CALS raster file formats. Refer to the list of documentation below for additional guidance in the implementation and use of CALS raster data.

6.6 -- Additional Documentation

ANSI/AIIM MS53 1993, "Standard Recommended Practice -- File Format for Storage and Exchange of Images -- Bi-Level Image File Format: Part 1".

> *Note:* *The Consultative Committee on Telegraph and Telephone (CCITT), has changed its name to "International Telecommunications Union Telecommunication Standardization Sector", or "ITU-T".*

- CCITT Recommendation T.503: 1984, Document Application Profile for the Interchange of Group 4 Facsimile Documents.

- CCITT Recommendation T.6: 1988, Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus.

- CDNSWC/CISD(18)-93/09, October 1993. A MIL-PRF-28002B Implementation: An informal Test and Evaluation using sample DoN Raster files.

- CDNSWC/CISD(18)-93/10, October 1993. AUDRE

- Dawson, F., and F. Nielson, 1990, ODA and Document Interchange, Unix Review, vol. 8, no. 3, March 1990, p.50.

- FIPS PUB 150: 4 November 1988, Telecommunications: Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus.

- FIPS PUB 194: Open Document Architecture (ODA) Raster Document Application Profile (DAP).

- ISO 8571: 1988, Information processing systems -- Open Systems Interconnection -- File transfer, access and management.

- ISO 8613-1: 1993, Information processing -- Text and Office Systems; Open Document Architecture (ODA) and Interchange Format -- Part 1: Introduction and General Principles.

- ISO 8613-2: 1993, Information processing -- Text and Office Systems; Open Document Architecture (ODA) and Interchange Format -- Part 2: Document Structures.

- ISO 8613-4: 1993, Information processing -- Text and Office Systems; Open Document Architecture (ODA) and Interchange Format -- Part 4: Document Profile.

- ISO 8613-5: 1993, Information processing -- Text and Office Systems; Open Document Architecture (ODA) and Interchange Format -- Part 5: Open Document Interchange Format.

- ISO 8613-7: 1993, Information processing -- Text and Office Systems; Open Document Architecture (ODA) and Interchange Format -- Part 7: Raster Graphics Content Architectures.

- ISO 8613-1: 1993, Information processing -- Text and Office Systems; Open Document Architecture (ODA) and Interchange Format -- Part 1: Annex F -- A Document Application Profile Proforma and Notation.

- ISO 8613-7: 1993, Information processing -- Text and Office Systems; Office Document Architecture (ODA) and Interchange Format -- Part 7: Amendment -- tiled Raster Graphics Addendum to ISO 8613, Part 7.

- ISO 8824: 1987, Information Processing Systems -- Open Systems Interconnection -- Specification of Abstract Syntax Notation One (ASN.1).

- ISO 8825: 1987, Information Processing Systems -- Open Systems Interconnection -- Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1).

- ISO 8879: 1986, Information processing -- Text and Office Systems -- Standard Generalized Markup Language (SGML).

- ISO 9069: 1988, Information processing -- SGML support facilities -- SGML Document Interchange Format (SDIF).

- ISO 9070: 1990, Information processing -- SGML support facilities -- Registration procedures for public owner identifiers.

- ISO/IEC International Standard Profile (ISP) 11181-1: 1992, Information technology -- Standardized Profile FOD26 -- Office Document Format: Enhanced document structure -- Character, raster graphics and geometric graphics content architectures -- Document

Application Profile.

- ISO/IEC International Standard Profile (ISP) 11182-1: 1992, Information technology -- Standardized Profile FOD36 -- Office Document Format: Enhanced document structure -- Character, raster graphics and geometric content architectures -- Document Application Profile.

- MIL-PRF-28002B: 1992, Military Specification, Raster Graphics Representation In Binary Format, Requirements For.

- MIL-STD-1840B: 1992, Military Standard, Automated Interchange of Technical Information.

- Rose, M.T., The Open Book: A Practical Perspective on OSI, Prentice Hall, Englewood Cliffs, NJ., 1990.

- Sharpe, L., Tiling: Turning Unwieldy Drawings into Neat Little Packets, Inform, Association for Image and Information Management, March 1989.

- Shuford, A., 1992, Report Comparing MIL-PRF-28002A Appendix A and Draft MIL-PRF-28002B Appendix A, CDNSWC/TM-12-92/71, Systems Department Technical Memorandum, David Taylor Model Basin, Carderock Division Naval Surface Warfare Center, Bethesda MD 20084-5000.

- Spielman, F.E, and Sharpe, L., 1991, Tiled Raster Graphics and MIL-PRF-28002A: A Tutorial and Implementation Guide, NISTIR 4567, National Computer Systems Laboratory, NIST.

- Spielman, F.E., and Sharpe L.H., 1993, Raster Graphics: A Tutorial and Implementation Guide, NISTIR 5108, Computer Systems Laboratory, NIST.

- Stable Implementation Agreements for Open Systems Interconnection Protocols: Part 23 -- ODA Raster DAP, September 1992.

- Stable Implementation Agreements for Open Systems Interconnection Protocols: Part 23 -- ODA Raster DAP, March 1993.

- Telecommunication Standards Sector (TSS) Recommendation T.417: 1993, Information Technology -- Open Document Architecture (ODA) and Interchange Formats -- Raster Graphics Content Architectures.

7.0 -- Digital Representation for Communication of Illustration Data: Computer Graphics Metafile (CGM) -- MIL-PRF-28003

7.1 -- Purpose

The Military specification, MIL-PRF-28003, "Digital Representation of Illustration Data: Computer Graphics Metafile (CGM)", specifies an application profile of the International and U.S. standards for CGM and certain specific additional requirements. The Computer Graphics Metafile standard is a

published International Standard (ISO/IEC 8632), a Federal Information Processing Standard (FIPS 128), and has been adopted by the American National Standard Institute (ANSI). The CGM standard is being developed and maintained through a coordinated effort of ISO SC24 and ANSI X3H3. The U.S. and international standards are identical.

MIL-PRF-28003 was first published 20 December 1988, was superseded by MIL-PRF-28003A published 15 November 1991. Amendment 1 to MIL-PRF-28003A was published 14 August 1992. MIL-PRF-28003B is currently under development and is expected to be released in the Autumn of 1997.

The overall intent of the CGM standard is to provide the lowest level of drawing functionality required to capture and reproduce a picture in a way that is portable across applications and devices. The CGM standard specifies two-dimensional graphics data interchange in a file format that can be created independently of device requirements and translated into formats needed by specific output devices, graphics systems, and computer systems.

A metafile is a device-independent, application-independent storage format for the exchange of the data that makes up a picture ("picture data"). The application software stores a picture in a metafile. To do this, it has to write all the information required to a file. The software that performs these writing actions is called the generator. The software that reads a metafile back into an application is called an interpreter. A profile addresses implementation conformance requirements for the generator and interpreter. A profile provides a way of standardizing and publicly specifying the options that a vendor supports and how they are to be supported.

MIL-PRF-28003 is the CALS Application Profile for CGM, developed to provide more information and requirements for specific application areas that relate to the CALS environment. It is designed for a multi-system environment that involves a wide range of applications. It is also designed to increase the conformance requirements for CGM, to guarantee final results when the pictures are drawn. All CALS CGMs conform to ISO/IEC 8632. It is important to note that CALS applications that use CGM conform to the MIL-PRF-28003 Application Profile, which is a subset of ISO/IEC 8632, and not simply to the CGM standard.

7.2 -- Typical Applications

MIL-PRF-28003 is intended for use in computer graphics applications in the following situations:

.   A graphics metafile is maintained at a central facility for a decentralized system that employs graphics devices of different makes and models that must utilize the data.

.   A graphics metafile is required to preserve picture data when conversion or migration from one graphics system to another is necessary and the two systems are not necessarily compatible.

.   A graphics metafile is intended for information interchange between a source system and a target system that are not necessarily compatible.

FIPS 128 in conjunction with MIL-PRF-28003 should be used when the representation of graphical information in digital form is to be used in technical illustrations and publications, and when the use of a

general-purpose, graphical interchange mechanism is required. The current version of FIPS 128 is FIPS 128-1, 11 May 1993. This FIPS adopts the redesignated version of the CGM standard known as ANSI/ISO 8632.1-4:1992.

ISO/IEC 8632 is the recommended standard to:

.   View the image on a wide variety of devices with different characteristics (such as color and resolution), where the set of devices may not even be known at the time the metafile is generated;

.   Enhance the picture before viewing the final image; and

.   Compose or overlay several drawings into a single picture for viewing.

7.3 -- Status and Planned Extensions

MIL-PRF-28003, first published 20 December 1988, was superseded by MIL-PRF-28003A published 15 November 1991. MIL-PRF-28003B is scheduled to be published in the Autumn of 1997. Following is a list of technical changes that will be included in MIL-PRF-28003B:

.   Restructure the specification to ensure compatibility with ISO/IEC 8632-1:1992 Amendment 1, Rules for Profiles,

.   Investigate adoption of existing International Standardized Profiles (ISP) or other commercial profiles (e.g., ATA 2100),

.   Investigate the harmonization of convergence of the requirements in MIL-PRF-28003 with the commercial application profile ATA 2100,

.   Increase upper bounds relating to size of some geometric entities,

.   Include additional features including Metafile Versions 3 and 4, and

.   Harmonize raster object encoding in CGM files with MIL-PRF-28002.

ISO/IEC 8632 CGM: 1992 Amendment 1 defines rules for writing profiles. This amendment includes rules for profiles, a model profile, and conformance requirements. ISO/IEC 8632 CGM: 1992 Amendment 1 was published in late 1994. It contains rules information that will be used to revise the CALS Application Profile (MIL-PRF-28003) for CGM. The "Model Profile" of Amendment 1 is similar to MIL-PRF-28003A. MIL-PRF-28003B will be upward compatible with 28003A.

ISO/IEC 8632 CGM: 1992 Amendment 2 Application Structuring contains structure and intelligent graphics information. Amendment 2 has been given a Draft International Profile status and is being balloted over a six month period. This amendment contains only change pages, therefore one should have the full standard in order to use and understand the amendment.

Of particular interest to the CALS environment is the work under way within the CGM standards

organization (X3H3) to provide "intelligent graphics". "Intelligent Graphics" is defined as adding information to graphics that is not graphical information, but that attaches application intelligence or semantics to the graphics. Requirements are association of comments with graphics elements, association of comments with element groups (hierarchical), native format editing, version control, and text to graphics links. This requirement was originally introduced by the "electronic Review" work of the CALS Industry Steering Group (ISG) Electronic Publications Committee, where SGML-tagged documents are used to provide a commenting capability. The CGM additions will allow for SGML tags to be attached to objects within the CGM file.

7.4 -- Implementation Issues

Although MIL-PRF-28003 has been available for some time, no vendor has fully implemented it, thereby causing confusion with users. Vendors who state they are "CGM-conforming" may not be MIL-PRF-28003 conforming. Some vendors actually have a problem with importing and exporting the same image; if a CGM file is imported and then immediately exported, it is changed. In other cases, CGM generators provide functionally satisfactory CGMs, but fail to provide the required identification elements.

In the area of text and font support, MIL-PRF-28003A calls out Hershey and proprietary fonts. Many of the problems encountered in the past should be solved through the use of metric equivalents of Times Roman and Helvetica fonts.

ISO/IEC 8632:1992 draws heavily from the ISO/IEC 8613: 1989 Amend 2 Open Document Architecture (ODA) Colour Addendum. The ODA Colour addendum has a second calibration matrix that ISO/IEC 8632:1992 does not include. This may cause some inconsistencies when CGM is used as the graphic content of an ODA document.

The OSE Implementors Workshop has developed an ODA profile with CGM content. The profile is a subset of Part 8 of ISO/IEC 8613 ODA. Many technical changes were made to the original profile as a result of comments from the CGM community. **Note:** Use of Part 8 in conjunction with MIL-PRF-28003A may produce nonconforming CALS metafiles.

7.5 -- Extent and Nature of User and Vendor Support

CGM is an established standard and has successfully been added to the list of input and output formats for off-the-shelf products.

7.6 -- Additional Documentation

- ISO/IEC 8632:1992, Information Technology -- Computer Graphics Metafile for the Storage and Transfer of Picture Description Information.

- Henderson, L. and Mumford, A.: "The Computer Graphics Metafile" Butterworth Series in Computer Graphics Standards.

- Henderson, L. and Mumford, A.: "The CGM Handbook", Academic Press, June 1993.

- NIST CGM Information Pack for Testing Conformance to the FIPS 128 and CALS CGM Application Profile, NIST.

- "How the CALS Program Should Utilize Computer Graphics Standards" Final Report, Dr. Peter Bono, October 10, 1986, NBS 43NANB615018.

- Kemmerer, S.J., October 1992, Computer-Aided Acquisition and Logistic Support (CALS) Testing: Program, Status, and Strategy, NISTIR 4940. Information Systems Engineering Division, Computer Systems Laboratory, NIST.

- Military Specification MIL-PRF-28003A:1991, Digital Representation For Communication of Illustration Data: CGM Application Profile (CGM AP).

- Rosenthal, L.S., November 1992, Report on the Raster Capabilities of MIL-PRF-28002A and MIL-PRF-28003A, NISTIR 4970. Computer Systems Laboratory, NIST.

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